MUSHROOM CULTIVATION: A BEGINNERS GUIDE SECOND EDITION

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MUSHROOM CULTIVATION: A BEGINNERS GUIDE

SECOND EDITION

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PREFACE

The **ZERI** Project at the University of Namibia promotes oyster mushroom farming in Namibia. **ZERI** stands for **Z**ero **E**missions **R**esearch **I**nitiative. ZERI is a **vision**, **concept**, and **philosophy** born and nurtured at the United Nations University (UNU) in 1994. It is a concept that directs our thinking towards looking at a wide spectrum of materials around us, and the rich biodiversity in our various ecosystems, which we often ignore, or conceive as useless, or as waste, with a view to transforming them into new, marketable, value-added products. The ZERI project has prioritized mushroom farming as one of its major research and development activities in Namibia. In **Namibia**, the key mushroom farming technology providers comprise the staff of UNAM's **Sam Nujoma Marine and Coastal Resources Research Centre** (SNMCRRC), **the Ogongo Agricultural College** and **the ZERI office** on the main campus. This manual has been prepared in support of this noble mission of the ZERI Project in Namibia.

The key inspiration for producing this manual is to empower Namibians to grow mushrooms for own consumption or as a cash crop to generate income and to create employment.

The purpose of this manual is threefold. Firstly, it introduces mushroom growers to **mushroom farming technology**. Secondly, it simplifies and localizes the knowledge shared in greater detail in *"A Guide to Successful Mushroom Farming: An agenda for developing Africa differently" by Prof Keto Mshigeni and Prof Shu-Ting Chang (2000).* Thirdly, it shares with the reader our experiences of mushroom cultivation and training in Namibia.

The main objective of the training manual is to equip the reader with the knowledge and skills on the growth of oyster mushrooms in Namibia. After training and with further reading of the manual, the participants should be able to:

- explain and apply the basic skills involved in the cultivation of oyster mushrooms
- prepare mushroom cultures and spawn ('seed')
- demonstrate how to avoid contamination in cultures and spawn
- identify different materials that can be used as mushroom substrates (materials where mushroom seeds are planted)
- prepare and inoculate substrates
- name different types of materials used to make spawn
- outline the different ways of treating the substrates
- describe the basic structure and components of a mushroom house and, where possible, be able to explain how it should be constructed;
- describe and demonstrate how mushroom houses should be maintained, e.g. watering, humidity and aeration and
- explain the post harvest process of oyster mushroom farming e.g. harvesting, packaging, preserving, and have basic knowledge of marketing their mushrooms

It is my sincere hope that you will make use of this booklet to become a mushroom farmer and entrepreneur who can be the beacon of hope and a role model to many others who may wish to adopt mushroom farming. I would like to thank the mushroom trainers and scientists Ms. Pauline Kadhila-Muandingi and Mr. Fabian Mubiana, as well as Prof. Osmund Mwandemele the ZERI Project Coordinator and UNU ZERI Chair, for encouraging the team to do everything possible to reach the communities through the ZERI Project. Many thanks should also go the Vice-Chancellor, Professor Lazarus Hangula, and his Management Team for the continued support provided to the ZERI Project.

It is through the University's commitment that the ZERI Project continues providing training and empowerment of communities countrywide. The financial support provided by UNDP, the United Nations University and NEDBANK is hereby greatly appreciated. It is our very great hope that through the use of this manual mushroom farming will be undertaken, in the long run, as one of the alternative income

generating activities adopted by many entrepreneurs and families throughout Namibia and beyond.

GLOSSARY

Aeration: Process, by which air is circulated through, mixed or dissolved in a liquid or substance.

Agar: An extract from seaweed used to solidify media. Agar is used in mushroom cultivation to provide growth conditions for the mushroom spores.

Autoclave: A steam-pressurized pot or vessel for generation of heat.

Biological Efficiency: This refers to the percentage measurement of yield of fresh mushroom from dry weight of substrate, e.g. 1kg of fresh mushroom from 1kg of dry substrate is 100% biologically efficient.

Colonization: The process of mycelia growing all over the substrate until the whole substrate is completely whitened.

Contamination: Unwanted organisms in the growing medium. This usually occurs due to insufficient sterilization of the medium. It is usually black or green moulds.

Culture Medium: Potato Dextrose Agar or Malt Extract Agar.

Culture: Mushroom Mycelia growing on medium.

Flush: Cropping of Mushroom that occurs as a sudden development of many fruit bodies within a defined period of time.

Fruit body: The mushroom structure.

Humidity: The amount of water vapor in the atmosphere.

Hygrometer: An instrument for measuring relative humidity or the amount of water in the atmosphere.

Inoculate: **T**he process of planting in mushroom cultivation

Mycelium: A fungal network of thread-like cells from where mushroom fruit bodies are formed.

Pasteurization: The process of heating liquid for the purpose of destroying viruses and harmful organisms such as bacteria, protozoa etc.

Petri dish: A round glass or plastic dish with a cover that is used to grow mushroom mycelium which will be used to inoculate mother spawn.

Pin Head: A term used to describe a very young mushroom when the cap has the size of a pin.

Preservation: Protection of food from deterioration by microorganisms, enzymes and oxidation.

Spawn: The pure culture of mycelium on grain, Sawdust used to inoculate the final substrate; it is also known as mushroom seeds.

Sterilization: Completely destroying all micro organisms present by heat using autoclave or pressure cooker.

Substrate: Straw, sawdust or nay organic materials on which mushroom mycelium will grow.

Temperature: The degree of hotness or coldness of a body or environment.

1. INTRODUCTION

1.1 Mushrooms

Mushrooms are macro fungi with characteristic fruiting bodies which are large enough to be seen with naked eyes and picked by hands. During its growth, a mushroom can decompose organic materials and absorb nutrients from it. Mushrooms can be a good source of protein which contains all the essential amino acids. Mushrooms are also high in fibre, rich in vitamins, and low in cholesterol. Mushrooms are commonly used for various dishes in different shapes and forms.

You will find mushrooms in forests around the world. Given the proper environment, mushrooms will grow and can offer a good source of natural vitamins and minerals. Mushrooms can also cause illness and even death to people who are unaware of certain types of wild mushrooms. Cultivated mushrooms are, therefore, to be preferred and are the most reliable source of supply.

Activity 1 10 minutes

List some of the nutrients that are found in mushrooms.

Why are cultivated mushrooms more reliable than wild ones?

The Southern African region has a rich diversity of mushrooms, some of which are still unidentified. Some known varieties include the *Termitomyces (Fig.1.5), Kalahari truffle* (Fig. 1.3), which can only be harvested during the rainy season and soon after.

The most commonly and easily cultivated mushrooms in most Southern African countries are Oyster mushrooms, *Pleurotus ostreatus*, *Pleurotus soja caju*, *Pleurotus HK35* (Fig.1.1) and Button mushrooms, *Agaricus bisporus* (Fig. 1.2). Other types of mushrooms such as *Lentinula* species *(Shiitake) (Fig.1.6)*, *Ganoderma* species (Fig.1.4), and other species can also be cultivated successfully but require more attention and technical skills. It is therefore recommended that new mushroom growers start with easy to grow and commercially viable mushrooms.

In Southern Africa, oyster mushrooms are successfully grown on locally available substrates such as, grass, maize and millet stalks, maize cobs and sawdust.

Fig 1.1 Oyster Mushrooms (Pleurotus ostreatus). (Photo by K. E. Mshigeni)

Fig 1.2 Button mushrooms (Agaricus bisporus) (Photo by CEFA)

***Fig 1.3 Kalahari truffle mushrooms (Terfezia pfeilli*) (Photo by K. E. Mshigeni)**

Fig 1.4 Ganoderma mushrooms growing wild on the tree stump (Photo by N.P.Kadhila-Muandingi)

Fig 1.5 Termitomyces on sale by the road side. (Photo by A. Mosimane)

Fig 1.6 Harvested Shiitake mushrooms ready for sale. (Photo by K. E. Mshigeni)

1.2 Why farming with mushrooms?

Mushrooms are very delicious, nutritious and medicinal. They are rich in vitamins, low in cholesterol and have protein that contains all essential amino acids required in human diet. Mushrooms have the most delightful aroma than most vegetables. In addition to nutritional qualities, mushrooms can also be cultivated to generate income and create employment.

Given the abundance of local materials (agricultural waste) that can be used as substrates and the many benefits of mushroom cultivation, the following part of this guide is dedicated to steps/ phases of cultivation techniques.

2. CRITICAL INFORMATION IN MUSHROOM CULTIVATION

2.1 Climatic conditions

The prevailing climatic conditions (temperature, humidity, rainfall) of a certain area are necessary in determining the type of mushroom to be grown. The above is also essential in determining the type of local materials found in that specific place, which

can be used as substrates. It is therefore important to study the environmental conditions before deciding on the type of mushroom to be cultivated.

2.2 Basic needs for mushroom cultivation

The following are essential before attempting mushroom cultivation:

- Manpower
- Mushroom culture
- Pasteurization chamber (200L drum) / Sterilization chamber (Autoclave)
- Inoculation box / Laminar Flow
- Fridge / Cool room
- Mushroom house (three room house)

3. MAJOR PRACTICAL PHASES OF MUSHROOM CULTIVATION

Following are the major phases in mushroom cultivation:

- Selection of suitable mushroom culture
- Development of spawn
- Substrate: Preparation and Spawning
- Mushroom vegetative and fruiting phase
- Harvesting and Packaging
- Marketing

Each of these phases is discussed in details below.

3.1 SELECTION OF SUITABLE MUSHROOM FOR CULTURE

This is the process whereby one obtains the tissue from the fresh mushroom in order to develop a pure culture for spawn production. A fresh, young healthy mushroom should be used to prepare the tissue culture. This procedure is very delicate and must be done under extremely sterile conditions. However, this may not be practical for beginners in mushroom cultivation but as one advances the technique becomes handier.

Fig2.1 Mushroom cultures. (Photo by K. E. Mshigeni)

3.1.1. Materials for culture preparation

The following materials are needed for culture preparation:

- Potato Dextrose Agar (Ready mixed powder)
- Malt Extract Agar (Ready mixed powder)
- Distilled or tap water
- Measuring cylinder
- 1L Volumetric flask / any heat resistant bottle
- Petri dishes/ test tubes

- Pressure cooker or Autoclave
- Pure culture (from research laboratory or reliable source) / Fresh mushroom
- Sterile surgical blades / sharp small knifes
- Bunsen burner / Spirit lamp
- Methylated spirit / Ethanol
- Cotton wool
- Parafilm

Activity 2 **10 minutes**

Which of the materials listed above do you have or can find easily in your area?

Discuss possible ways/ solutions for obtaining the materials you do not have in your area.

3.1.2 Procedures

Below are procedures to be followed in culture preparation:

a) Dissolve 39g of Potato Dextrose Agar or 50g of Malt Extract Agar in 1L distilled or tap water in a volumetric flask or heat resistant bottle
b) Boil until completely dissolved and autoclave at 121°C for 15 minutes. Alternatively cook in a pressure cooker or steam pot for 1 hour
c) Cool the media to at least 50°C or until one is able to hold the flask without burning
d) Disinfect your hands, the area where you are going to work and the apparatuses by wiping with 70% alcohol, ethanol or methylated spirit
e) Pour the solution in Petri dishes or clear flat bottles to about 2.5cm from the bottom. Cover the Petri dishes and plug the test tubes with disinfected cotton wool immediately and let it solidify
f) Sterilize the blades or knife with 70% ethanol and aseptically cut a piece from the pure culture and with the mycelia side down, place it on the agar in the Petri dishes or bottles (fig.2). Alternatively, cut a tissue from the fresh mushroom and place it on the agar in the Petri dish or test tube
g) Cover the Petri dish or bottle (with cotton wool) and seal with Para film
h) Store at room temperature in a dark place and in 5 to 10 days the mycelia will cover most of the surface of the agar. Keep the cultures which are not used immediately in a fridge at 4°C. It is recommended that cultures should be used up within 30 days after inoculation.

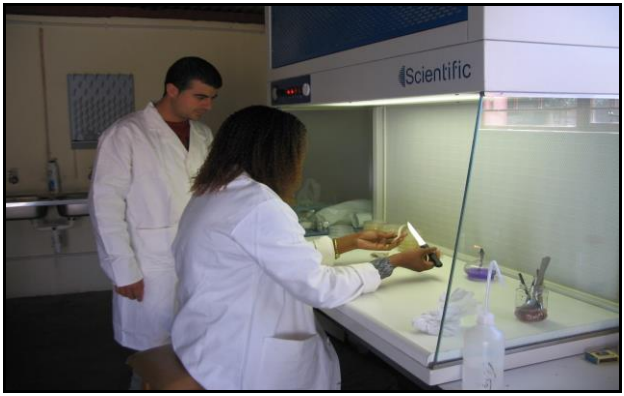

Fig.2.2 Preparing tissue culture from a fresh mushroom (Photo by K. E. Mshigeni)

3.2 DEVELOPMENT OF SPAWN

During this phase, pieces of tissue culture are transferred to bottles containing grains to develop mushroom seed, the spawn. The mycelia grow on the grains, until the whole bottle is colonized, and ready to inoculate the substrate.

Fig.2.3 Fully colonized bottles of spawn (Photo by F. Mubiana)

3.2.1 Materials for spawn preparation

The following materials are needed for culture preparation:

- Grains (e.g. sorghum, wheat, millet or maize)
- Cooking pot
- Heating sources (e.g. fire or electric plate)
- White chalk or dehydrated building lime
- Wheat bran / millet or maize husk
- Bottles (e.g. mayonnaise or tomato sauce bottles thoroughly cleaned)
- Mushroom culture / mother spawn
- Methylated spirit / Ethanol
- Cotton wool / Jumbo paper
- Bunsen burner / Spirit lamp
- Inoculation box / thoroughly cleaned room or space

3.2.2 Procedures

Below are procedures to be followed in spawn preparation:

a) Soak the grains in water overnight or cook it slowly until it has absorbed enough water. The optimal moisture content for spawn mycelia invasion is 40-60%
b) Remove the grains from water, drain excess water, mix with 1.5% white chalk or lime of the dry weight of the grains and put in clean bottles up to 2/3 full. Close the bottles slightly
c) Autoclave the bottles at 121°C for 15 minutes or cook in a pressure cooker for 1 hour
d) Cool the grains prior to inoculation
e) Disinfect your hands, the area where you are going to work and the apparatuses by wiping with 70% ethanol or methylated spirit
f) Sterilize the blades or knife/spoon with 70% ethanol or methylated spirit and cut 3 to 4 pieces of culture from the plate (depending on the size of the bottle). Slowly shake the bottles to mix the culture with the grain and replace the cap

g) Keep the bottles at room temperature in a dark place until the grains arefully invaded by the mycelium, which takes about 2 weeks. Once the grains are fully invaded, the spawn is ready to be used for substrate inoculation. This is now your mushroom seed

h) Keep all bottles which are not used immediately in the fridge and use within threes months.

3.3. Substrate preparation

This is the phase whereby raw materials are inoculated with the spawn. Raw materials mostly agricultural wastes which are readily available are some of the best substrates for mushroom cultivation (Fig. 2.4). Mushroom substrates can be simply defined as organic materials which support the growth, development and fruiting of mushroom mycelia. These materials are a mixture of all ingredients or food necessary for mushrooms development. Sawdust can also be used but care must be taken not to use the chemically treated sawdust. This is because the chemicals might inhibit mycelia growth and when absorbed by the mushrooms, it can be harmful for human consumption.

3.3.1 Materials for substrate preparation

The following materials are needed for substrate preparation:

- Substrate (maize, millet or sorghum straw, millet shaff grass, corn cobs, saw dust)
- Transparent, heat resistant plastic bags
- Tying ropes / Sealing machine
- Lime
- Weighing Scale (optional)
- Spade / Garden folk
- 200L Drum / Autoclave
- Heat source e.g. firewood
- Mushroom spawn
- Spirit lamp

- 70% Ethanol / Methylated spirit

Fig.2.4 The Community busy preparing substrate. (Photo by F. Mubiana)

3.3.2 Procedures

Below are procedures to be followed in substrate preparation:

a) All raw materials, must first be cut into smaller pieces of 1-5cm long
b) Weigh the dry substrate to help determine the biological efficiency
c) Soak the substrate in water overnight and squeeze it to optimal moisture content which is 50-60% or until no water drips out when squeezed
d) Mix the substrate with 1-1.5% lime (% of the dry weight of the substrate)
e) Pack the substrate into bags and sterilize or pasteurize them in the autoclave or drum respectively (Fig.2.5)
f) Let the substrate cool down and inoculate with the pure spawn under sterile conditions
g) Keep the inoculated bags in a dark placed until they are fully colonized by the mycelia.

Fig.2.5 Training participants pasteurizing substrates (Photo by L. Horn)

3.4 Vegetative phase

This is the phase when the bags are kept in the dark room for mycelia invasion. During this phase, the bags should be thoroughly inspected for contamination (Fig.2.6a, 2.6b). Contaminated bags should be immediately removed from the room, sterilized or pasteurized and re-used as compost, animal feed and substrate.

Fig.2.6a Inspecting the bag to see if it is fully invaded by mycelium (Photo by F. Mubiana)

***Fig.2.6b A bag almost fully invaded by mycelium (*Photo by *K. E. Mshigeni*)**

3.5 Fruiting phase

This is the phase when the bags start producing fruiting bodies. This happens after the bags are fully invaded by the mycelia. At this stage, the bags must be kept in a room where temperature and humidity can be controlled and if possible where sprinklers and nozzles have been installed. The fruiting room should also be well aerated.

Make open cuts on the bags where the mushroom will start sprouting. Use a knife or scissor to cut. By spraying the room, the humidity is raised and the temperature controlled, especially during summer. The optimum temperature for most mushrooms is in the range of 15-35°C and humidity of 80 – 95%.

Fig.2.7a Fruiting mushroom bag (Photo by F. Mubiana)

The first fruits appear in 4 weeks from the day the bags were inoculated and take about 3-5 days to become full grown mushrooms and ready for harvesting.

3.6 Harvesting

Harvesting should be done at least twice a day or when mushrooms are at an appropriate size, depending on customers' preferences. Avoid harvesting outgrown mushrooms because they have less flavour, and if harvested too small they cannot fetch a good price on the market.

Mushrooms must be harvested using hands, by unplugging the clusters. Never use a knife to cut them off because this minimizes the chance of the bag pinning again. Fresh mushrooms should never be kept in plastic bags, as this accelerates deterioration.

Fig.2.7b Fruiting bag ready for harvesting (Photo by K. E. Mshigeni)

3.7 The Bioconversion Efficiency

The Bioconversion Efficiency is the effectiveness of mushrooms in changing lignocellulose substrates into mushroom biomass. The Bioconversion Efficiency is calculated using the formula below.

$$\%\ Yield = \frac{Mass\ of\ \ fresh\ mushrooms}{Weight\ of\ dry\ substrate}$$

4. PACKAGING AND QUALITY CONTROL

Quality products sell; make sure that the mushrooms are of good quality

- Harvest young mushrooms for longer shelf life and better taste
- Trim the mushrooms and grade them accordingly
- Weigh and pack in paper bags or Styrofoam plate
- Store in the refrigerator if not for immediate use or sale
- To avoid humidity accumulating in the bags, aerate the bags

5. PRESERVATION AND PROCESSING

Mushrooms are highly perishable, so strategies in preservation techniques are necessary. Oyster mushrooms can be kept in the fridge for at least 7 days. Drying is a good option since it allows mushrooms to be used in different forms. Drying can be done naturally in the sun using baskets or on special mats. Mushrooms should be sliced to accelerate drying. Care should be taken to prevent dust and soil particles from mixing with mushrooms. However, drying scan also be done with electrical and solar dryers.

Many products can be made from mushrooms. Apart from being processed into soups and sauces, mushrooms can be processed into sweets, cookies, candies and various snacks. In a nutshell, these are some ways of adding value to mushrooms.

6. MARKETING

Mushrooms can be sold directly to consumers or to wholesalers. However, make sure that the surrounding communities are aware of your products by advertising on board signs or using any local media.

The profit will be reduced when dealing with an intermediary but if a good agreement can be reached, it also saves on expenses related to marketing. Prices of mushrooms will depend on the season and the type. Different seasons will give better yields for certain mushrooms.

6.1 Sales outlets

Mushrooms like any other products need to be marketed. Below are some ideal market places:

- On farm marketing
- Local / Open market
- Restaurants and Hotels
- Supermarkets

Brainstorming!!

Think of possible places in your area where you can sell your mushrooms after harvesting

7. MUSHROOM HOUSES

A mushroom house is a place where mushrooms are growing. This is where fully colonized bags are kept. This house should be built in such a way that it can maintains enough humidity and be able to keep warm in winter and cool in summer. Ventilation plays an important role, so the house should have windows. Mushroom houses vary from modern structures built with bricks to those built traditionally using mud, logs and grass. (Fig. 2. 9a - 2. 9f). Traditional structures with minor modifications are the ideal mushroom houses.

Fig.2.9a A modern thatched mushroom house (Photo by K. E. Mshigeni)

Fig.2.9b A modern Brick mushroom house (Photo by N. P. Kadhila-Muandingi)

Fig.2.9c Mushroom house made from reeds and thatching grass. (Photo by F. Mhanda)

Fig.2.9d Mushroom house made from poles and reeds. (Photo by A. Mosimane)

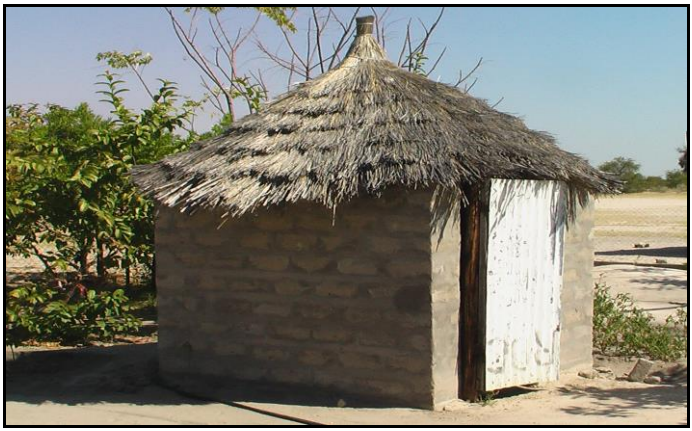

Fig.2.9e Mushroom house from cement bricks and thatching grass (Photo by A. Mosimane)

Fig.2.9f Mushroom house made from poles and thatching grass (Photo by A. Mosimane)

7.1 Materials for constructing a mushroom house

Below is a list of locally available materials that can be used to construct a mushroom house:
Straw, grass, reeds, tree branches, shade nets, clay or cement bricks, corrugated iron and styrofoam blocks. It is however recommend that the farmer uses materials that are readily available in their surroundings, instead of using expensive materials.

8. MAINTAINING AND MONITORING THE MUSHROOM HOUSE

Mushrooms are a reflection of where they are grown. In order to succeed, the mushroom grower should take very good care of the mushroom house. The following can serve as guidelines:

- The house should be far from pollutant sources (e.g industrial areas, dumping Sites and any other harmful objects)
- Sprinkle water to control humidity in the mushroom house
- Humidity should be maintained between 80 - 95%
- Water should not enter the bags after pinning (when mushrooms start germinating)
- Monitor the temperature to control the condition in the mushroom house
- If the temperature is too high, leave the windows open during the night
- Open and close doors and windows of the mushroom house to control light and ventilation
- Check for mites and other pests every day and identify their type and how to control them
- Identify contaminated bags and sterilize before disposing them to avoid the spreading of contamination
- Design a record keeping manual for your mushroom house.

9. PRODUCTION CYCLE

Production is a continuous process, make sure you always produce continuously by following the next steps:

Step 1: Prepare the first mushroom bags

Step 2: Keep the mushroom bags in the colonization room

Step 3: As soon as the bags are fully colonized move them to the fruiting room and open them

Step 4: Start preparing new bags to fill the colonization room again

Step 5: As soon as the bags in the fruiting room are exhausted / used up, replaced them with fully colonized ones to continue with the cycle.

10. WASTE MANAGEMENT AND RECYCLING

All production produce wastes and mushrooms are no exception. There is however such an easy way of dealing with waste from mushroom production. The following is recommended:

- Waste must be handled properly in each step of the mushroom cultivation process
- Spent substrates can be used as compost or animal feed
- After soaking, the water can be used for watering the garden since it is rich in nutrients from the soaked substrates
- Recycling and utilization of wastes is not only a good way of preserving our environment but also of saving money.

11. TROUBLE SHOOTING

As the saying goes,**"Preventing is better than solving problems",**this will help in solving some problems occurring in mushroom cultivation:

PROBLEM	CAUSE	SOLUTIONS
Mycelium fails to grow	Improper initiation strategy	Consult parameter of growth. Alter moisture, temperature, light, carbon dioxide, etc. ***Note:*** ***Provide optimal conditions***
	Bad substrate	Check substrate. Spread the substrate and remix it, repack and pasteurize again and make sure all raw materials are good and fresh. ***Note:*** ***It is necessary to pasteurize immediately after bagging;***

		otherwise fermentation gas will slow down the rate of growth of the mycelium or stop mycelium growth.
	Insufficient pasteurization	Make sure there is continuous steam for a period of 2 hours. ***<u>Note:</u> You should start counting hours when the water starts to boil.***
	Substrate in the bag was too hot during inoculation	Make sure that the substrate bag is cooled
	Bad strain or spawn	Obtain pure strain of known vitality & history Obtain spawn from a trusted source
	Spawn contaminated	Re-pasteurize the substrate and inoculate again with good spawn. Obtain spawn from a trusted source
	Forgot to inoculate the bag.	Make sure all bags are inoculated.
Poor mycelium colonization, bad smell, spots and mites.	Substrate has more water than needed which causes microbial development, that in turn causes the smell.	Ensure that excess water is drained from the substrate.
	Inoculation process.	Inoculate under hygienic conditions Disinfect the working area

		Keep the room closed
	Too many bags in the incubation room, which suppresses ventilation	Space the bags accordingly to create room for ventilation in the incubation area. Maintain the optimum temperature
	Unygienic conditions in the incubation room	Clean the room often
	Mycelia develop in patches because substrate is not evenly mixed and some parts have more nutrients than others	Mix the substrate well
	Bacteria or other fungi contamination.	Check the cause of contamination. Separate and discard contaminated bags from the rest as soon as possible. Ensure that inoculation is done under sterile conditions
	Mite contamination.	Immediately separate contaminated bags and discard. ***Note: *Keep hygiene management; make sure to clean everything (person, area, tools, equipment, and surroundings) during every step.*** ****Stop using the area to cut the life cycle of all contaminants for a***

		period of at least 1-2 weeks. For serious contamination cases, disinfect the whole area.
Mycelium grows but fails to produce mushrooms.	Low nutrient substrate Unfavorable climatic conditions	Adjust the formula; check pH; temperature and humidity.
	Presence of mites, mold, viruses, bacteria and insects.	Check pasteurization process, inoculation, and mushroom house management for hygiene.
	Degeneration	Acquire new strain from a reliable supplier
Primodials form, but abort or retarded growth	Optimal growth conditions not met.	Check temperature and humidity. Open or close doors and windows to adjust accordingly
Mushrooms form, but stems are long and caps are underdeveloped.	Inadequate light.	Allow more light in the room by opening windows or doors
	Excessive carbon dioxide.	Increase air movement, open doors or windows and close at correct time. (mornings and evenings).
Massive numbers of mushrooms form but few develop.	Too long incubation incubation time	Open the bags as soon an they are fully colonized
	Lack of oxygen, inadequate light.	Increase ventilation and open more windows or doors to receive more light.
	Imbalanced substrate nutrients	Reformulate or check raw the materials.

Mushrooms are deformed, decay and die.	Presence of other microorganisms.	Maintain optimal conditions for mushroom growth
	Not enough ventilation, too high humidity.	Increase air circulation. Reduce humidity to the prescribed levels. Avoid direct watering of bags. Pierce bags to drain water.
Mushrooms produced only in the first flush, fail to produce subsequent flushes.	Inadequate substrate nutrition.	Reformulate.
	Competitors / Contaminants	Check hygiene; adjust light, temperature, humidity, and ventilation.
	Poor strain.	Acquire new strain.
Small sized mushrooms	Too many mushrooms coming out at the same time.	Reduce the size of opening to control pinning.
	Insufficient nutrients in the substrate.	Reformulate
	Change of weather	Maintain optimal conditions inside mushroom house
	Poor quality spawn	Check origin of spawn.
Insect pests	Natural occurrence, humid climate.	Maintain hygienic conditions inside and in the surrounding of the mushroom house
	Mushroom waste lying around mushroom house.	Do not keep the spent substrate near the mushroom house Compost the substrate and use for gardening

Dehydrated mushrooms	Shortage of water.	Water the mushroom house as required
Short shelf life of mushrooms	Mushrooms overgrown when harvested.	Harvest when younger, 3-4 days after sprouting. Do not water directly on the fruits.
	Mushrooms too wet when harvested.	Reduce humidity several hours before harvesting. Do not harvest at least before 3 hours after watering.
	Mushrooms stored beyond shelf life.	Sell mushrooms faster, or dry them.

12. MUSHROOM RECIPES

12.1. Mushroom soup

Ingredients

Mushrooms
Garlic
Butter/Cooking oil
Salt (garlic salt or normal table salt) and
Onions

Procedures

Slice or tear the mushrooms in the shapes you like
Cut the onions
Melt the butter together with the onions until the onions become tender
Add the mushrooms
Cook at low heat, preferably at 3, if using an electric stove
Keep stirring until the mushrooms become juice
Do not add water
Add milk or cream, if necessary, or add the mushroom or vegetable soup
Add salt to taste and
Serve with macaroni, rice or porridge (pap)

12.2. Chicken Mushroom

Ingredients

Mushrooms
Garlic butter/normal Rama butter
Salt
Black pepper
Onions and
Chicken breast (chicken fillet)

Procedures

Chop the chicken fillet in small pieces
Slice the mushroom or tear them
Fry the chicken in garlic butter together with the mushroom
Add mushroom soup or vegetable soup
Do not add water, mushroom contains a lot of water
Add pepper, but not too much
Serve with rice or any other preferred food.

12.3. Mushroom Curry

Ingredients

Mushrooms
Curry powder
Garlic butte
Salt and
Onions

Procedures

Slice the mushrooms
Melt butter and the onions until the onions are tender
Add curry and mushrooms
Keep stirring till it become juicy
Add mushroom soup or vegetable soup (Do not add water)
Add salt to taste
Best served with rice

Enjoy the mushrooms with the complements of Mrs. Pauline Kadhila-Muandingi.

13. END NOTE

The guide is designed to guide in the basics of mushroom cultivation and farming. This is something new in our country, but we hope you are now familiar with this very important aspect of farming. The information in this document is worth sharing with other people in your area. You can start farming on your own or do it as a group.

Finally, we would like to reiterate that mushrooms are a vital source of nutrients for you and your family as well as a potential source of income. We have the right conditions and suitable local materials for mushroom farming. Therefore, let us embrace this promising farming practice. If you need more information or encounter any problem, you can contact:

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